

# NAVAL RESEARCH LABORATORY NAVAL CENTER FOR SPACE TECHNOLOGY

Product Assurance Plan  
for the  
Full-Sky Astrometric Mapping Explorer

**NCST-D-FM005**

**08 December 2000**

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## 1. INTRODUCTION

### 1.1 Purpose.

This plan establishes the requirements for product assurance on the FAME program. This plan identifies the existing NCST processes and procedures that shall be used in the design, development, procurement, fabrication, testing, and verification on the FAME flight hardware and its supporting equipment.

The main elements in assuring a quality product are the control of the design and verification that the hardware meets the design requirements. Part of this process is covered in the *FAME Configuration Management Plan*, NCST-D-FM008, which specifies, in detail, the method for controlling the FAME design and design documentation.

Another major part of the quality process is materials and parts control as specified in the *FAME Safety, Reliability and Quality Assurance (SR&QA) Plan*, NCST-D-FM006. A third element in assuring a quality product is the *FAME Test Plan*, NCST-TP-FM001.

This product assurance plan makes reference to these three supplemental documents where appropriate and provides the remaining elements for product assurance. These remaining elements are controls and the verification process.

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## 2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein.

### Military Standards

Number	Title	Paragraph Cited
MIL-STD-45662	Calibration Systems Requirements	12.1, 12.3

### NCST Manuals

Number	Title	Paragraph Cited
NCST-MCP-001	NCST Manual for Control Procedures	3, 13.1
	Configuration Item Verification, CP-03.03	13.3
	Intermediate Turnover Points, Audits and Preparation for Shipment, CP-03.04	8.1, 13.02, 13.4
	Development and Maintenance of the Engineering Configuration List (ECL), CP-09.07	5, 13.3
	Travelers, CP-11.02	8.2
	Logbooks, CP-11.05	8.2
	Development and Maintenance of the As-Built Configuration List (ABCL), CP-11.06	13.3
	Acceptance Test Requirements and Procedures, CP-15.02	8.3
NCST-MMP-001	Test procedures and As-Run Test Records, CP-15.04	8.4
	NCST Manual for Manufacturing Procedures	3, 13.1
NCST-MQA-001	Development and Control of Standard Processes, MP-11.01	7.3
	NCST Manual for Quality Assurance Procedures	3, 13.1
	Vendor Inspections and Qualification Review, QA-02.01,	6.2
	Procurement Package Review, QA-03.01	6.1
	Receiving Inspection of Parts and Materials into Secure Stores, QA-05.01	6.4
	Receiving and Inspection of Printed Wiring Boards, QA-05.02	6.4
	Nonconforming Material Reports, QA-14.01	9.1
	Discrepancy Reports, QA-14.02	9.3

## NCST-D-FM005

### NCST Documents

Number	Title	Paragraph Cited
NCST-D-001	NCST Product Assurance Guidelines	3
NCST-D-FM006	FAME Safety, Reliability and Quality Assurance (SR&QA) Plan	1, 6.5
NCST-D-FM008	FAME Configuration Management Plan	1, 5
NCST-SDP-FM001	FAME Software Management Plan	10
NCST-TP-FM001	FAME Test Plan	1

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### 3. NCST PRODUCT ASSURANCE PROGRAM

The NCST product assurance program consists of the product assurance guidelines contained in NCST-D-001 and a set of manuals and procedures. These procedures are organized so that a program manager can adjust the level of control and verification based on the size of the project, cost constraints and mission objectives while maintaining a high probability of mission success.

Top level procedures that involve the program office and which control major aspects across engineering, configuration management, manufacturing, and quality assurance are contained in the *NCST Manual for Control Procedures*, NCST-MCP-001. This manual contains the procedures for configuration control and configuration verification. Manufacturing Procedures are contained in NCST-MMP-001 and Quality Assurance Procedures are contained in NCST-MQA-001.

Figure 3-1 summarizes the flow from design through manufacturing, test and verification, and contains reference to the processes and procedures to be used.

**Figure 3–1. Quality Program Flow Chart**

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## **4. QUALITY ASSURANCE SUPPORT TO DESIGN**

Design reviews are recognized as key elements in the development of the FAME system. Primary responsibility for the success of a design review rests with the program manager and with the design and quality assurance staffs.

### **4.1 Quality Assurance Participation in Design Reviews.**

The development of FAME will utilize the following reviews.

- a. System Requirements Review (SRR) - Presentation for the understanding of the quality assurance requirements and delivery of this plan in a preliminary version.
- b. Preliminary Design Review (PDR) - Presentation of the development results and design approach for the flight hardware.
- c. Critical Design Review (CDR) - Presentation of the final design with a goal of 90% release of production documentation.
- d. Flight Component Review (FCR) - The official buy-off of major flight components. The component level to be specified by the program office. The review consists of functional audit and physical audit results and the As-Built Configuration List (ABCL) to Engineering Configuration List (ECL) verification.
- e. Test Readiness Review (TRR) - Presentation of the test plan, test procedure, test equipment, and test article status to obtain program office approval and buy-off of the unit as being fully qualified for system level test.
- f. Pre-Ship Review (PSR) - System level buy-off of the integrated vehicle prior to shipment to the launch site.
- g. Flight Readiness Review (FRR) - Review of ground systems and flight operational documentation.

The quality assurance participation in the formal design reviews shall consist of presentations of the findings and accomplishments in the proceeding development phase, and the planned quality assurance efforts and accomplishments in the next development or production phase.

### **4.2 Design Review Data Packages.**

The quality and timely submittal of the design review data packages is an important contributing factor to a successful design review. The quality assurance function has a portion of the responsibility of enabling the data package preparation as well as the generation of specific content items.

The quality assurance portion of the review data package for each review is the summary of the hardware status at that particular point in the review cycle. For PDR, this is primarily a planning package with little or no hardware status.

The quality data package for FCR and TRR are the major review packages for pivotal points in the development phase. These data packages are described in detail in section 13.

## 5. DESIGN AND DOCUMENTATION CONTROL

All flight hardware production drawings, assembly drawings, and procurement specifications will be released and put under configuration control in accordance with the *FAME Configuration Management Plan*, NCST-D-FM008.

All mechanical parts shall be inspected to released drawings. All mechanical assemblies and top assemblies shall be fabricated to released drawings.

Electronic parts and components can be purchased using unreleased schematics. Electrical schematics will be released prior to or in conjunction with the release of circuit card assemblies. Printed wiring board drawings shall be released prior to the fabrication of flight boards. Electrical Circuit Card Assembly (CCA) drawings must be released prior to the transfer of the CCA kit to manufacturing.

Release records will be contained in the computer database of the engineering records file. The file is maintained by the configuration management group. These records will be used to generate the ECL.

Engineering will verify the completeness and accuracy of the ECL and quality assurance will check and verify the ECL prior to a manufacturing or assembly step. For circuit card assemblies, the ECL will be validated as part of the kit preparation and inspection.

A detailed description of the ECL and the design control process are contained in Development and Maintenance of the Engineering Configuration List (ECL), CP-09.07 and the *FAME Configuration Management Plan*, NCST-D-FM008.

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## **6. PROCUREMENT CONTROL AND RECEIVING INSPECTION**

### **6.1 Procurement Document Review.**

Quality Assurance shall review for adequacy of quality requirements prior to release. Detailed quality requirements, as necessary, shall be included, or technical documents containing these requirements shall be referenced. Applicable revisions of referenced documents shall be indicated and documents provided, as necessary, to the procurements sources.

Purchase orders will be reviewed and the necessary quality assurance deliverables and certificates identified in accordance with procedure QA-03.01, Procurement Package Review.

### **6.2 Source Selection.**

Procedures shall be included for the control of purchased articles and shall include an evaluation of prospective procurement sources based upon previous and continuous record of supplying quality articles, materials, or services of the type being procured. The quality records shall be supported by documented qualitative and quantitative information, as necessary. Pre-award surveys of the procurement source facilities and quality system shall be conducted, when necessary, in accordance with procedure QA-02.01, Vendor Inspections and Qualification Review, to determine the capability of satisfying the program's quality requirements.

### **6.3 Source Inspection.**

Quality assurance shall provide for the assignment of contractor or NCST quality assurance personnel at subtier facilities as deemed necessary to conduct appropriate quality assurance activities, including inspections for compliance to the applicable program requirements.

### **6.4 Procured Parts and Materials Receiving Inspection.**

Procured articles shall be inspected upon receipt. Inspection shall verify conformance with the requirements of the purchased agreement and applicable space system program requirements

Parts and materials deemed acceptable by receiving inspection shall be so identified by records maintained to clearly indicate this acceptance. Parts and materials not meeting program standards shall be identified, isolated, and processed as nonconforming material per the approved procedures as described in section 9.

All incoming EEE parts will go through receiving inspection and be handled according to QA-05.01, Receiving Inspection of Parts and Materials into Secure Stores or QA-05.02, Receiving and Inspection of Printed Wiring Boards.

### **6.5 Electronic Parts Program.**

The FAME electronic parts program is described in the *FAME Safety, Reliability and Quality Assurance (SR&QA) Plan*, NCST-D-FM006.

## **7. FABRICATION**

FAME hardware shall be fabricated under stringent controls that assures all operations are performed by qualified personnel per configuration controlled drawings or written instructions with any deviations recorded for review prior to continuation of the processing. Traceability controls shall be applicable throughout hardware fabrication.

### **7.1 Fabrication Documentation.**

Fabrication records shall be created and maintained for all flight hardware builds. The key fabrication record shall be the traveler. They are used to document all traceability data, fabrication and assembly operations, inspections, and Testing. Travelers are uniquely numbered and travel with the hardware as it passes through all processing and inspection steps. In addition to travelers, assembly procedures may be used. The assembly procedure lists all the fabrication operations in sequence, provides all the necessary instructions by detailed descriptions or reference to other procedural documentation and allows for recording the operator's and inspector's identification as appropriate and the results of the process. The fabrication control documents, supporting procedures and assembly drawings are to be released prior to the start of the hardware build.

The quality assurance records and assembly logbooks generate a fabrication history of each unit that identifies not only the operator and date of each fabrication element but also the revision of all the documentation involved in the process step. A fabrication history or "built log" of the flight units will be developed including the revision level of each fabrication control document employed in the fabrication process such that questions raised subsequently can be answered without speculation or assumption. It is the responsibility of the lead engineer to prepare the build log and quality assurance to review the build log.

The complete fabrication documentation package including drawings, process procedures, traveler, and logbooks receive engineering approval prior to the start of fabrication.

### **7.2 Fabrication Control.**

The fabrication operations are required to be performed by trained production personnel with certifications applicable to operations. Flight units shall be fabricated in controlled production work areas.

The various procedures used in fabrication control are noted in Figure 3-1.

### **7.3 Process Controls.**

Process procedures, also known as process specifications, shall be released and put under change control. The process procedures include metallurgical and chemical processes, metal joining processes, bonding processes, plastics application, plating and coating processes and surface treating processes. In addition, evaluation processes such as radiography, ultrasonics, liquid penetrant and magnetic particle shall be controlled to ensure that the results accurately indicate the article or materials quality levels. For Process Control, see MP-11.01, Development and Control of Standard Processes.

### **7.4 Workmanship Standards.**

Workmanship standards shall be used to control the quality of workmanship. Documented workmanship standards of contractors shall be submitted for approval by NCST. The NCST workmanship standards are available for application by contractors in lieu of their own or as a guide in developing acceptable criteria for space systems.

### **7.5 Traceability.**

Material traceability is required on all components. A system for categorizing electronic parts into sets of homogeneous groups and tracing those parts through the fabrication, assembly, test, and delivery cycles shall be maintained. All materials and part traceability will be included in the traveler and logbook. The item's part and material shall be traceable from the initial source of material through the completed hardware. Parts shall be traced by part number, serial number (when available), and lot number as summarized in Table 7-1.

**Table 7-1. Traceability and Lot Control**

<b>Part</b>	<b>Relevant Information</b>
Electronic Piece Parts	Manufacturer/Date/Lot Code
Printed Circuit Boards	Serial Number
Potting/Adhesives/Coatings	Batch Number
Modules and Assemblies	Serial Number
Connectors	Manufacturer Lot Number and Date Code
Chassis Case/Structures	Lot/Heat Treat Number
Raw Materials	Certificate of Compliance/ Part Number
Fasteners	Hardware Certification
Wire/Cables	Certificate of Compliance/ Part Number

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## **8. INSPECTION AND TEST**

### **8.1 Inspection and Acceptance Test Points.**

Inspection points will be specified at key points in the manufacturing or assembly procedure. inspection records will be prepared and included in the logbook for the component or assembly. See procedure CP-03.04, Intermediate Turnover Points, Audits and Preparation for Shipment.

Acceptance test points will also be specified in the assembly procedure and as-run test results included in the logbook.

### **8.2 Inspection and Test Records.**

The inspection and test operations shall be incorporated into the travelers and thus provide a record of the personnel, the inspection date and a summary of the results. Detailed data recording will be incorporated into the fabrication history and logbook. See procedures CP-11.02, Travelers and CP-11.05, Logbooks.

### **8.3 Test Procedures.**

The test procedure is a controlled item that is subject to Configuration Control Board (CCB) review and approval prior to its use. The test procedures shall be under an engineering configuration control system and shall include the following items in accordance with procedure CP-15.04, Acceptance Test Requirements and Procedures.

- Test sequence, test parameters, and test conditions (including environments).
- Hazardous situations or operations and precautions to comply with established safety requirements to ensure safety of personnel, and to prevent damage or degradation of articles and measuring equipment.
- Test configuration diagrams and test schematics.
- Test equipment list.
- Quality Assurance sign-off for verification of critical measurement or settings of test hardware.
- Test method descriptions and specific data to be recorded including details or instructions for operation of special data recording equipment, or other automated test equipment.
- Acceptance limits for each measured parameter and acceptance criteria for nonquantitative evaluation.
- Test data sheets.

### **8.4 As-Run Test Records.**

As-run test records including one time only redline and real time redline modifications will be prepared in accordance with procedure CP-15.04, Test Procedures and As-Run Test Records.

## **9. NONCONFORMING MATERIAL AND FAILURE CONTROL**

### **9.1 Nonconforming Material.**

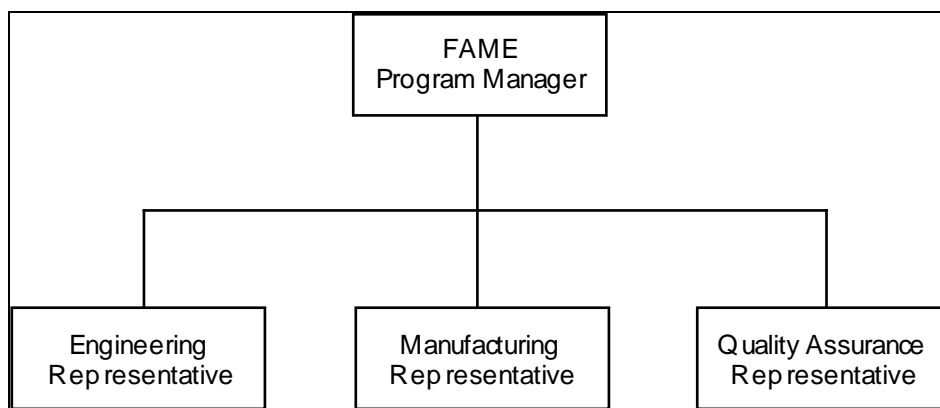
Material and components that do not conform to the engineering drawings shall be identified and controlled. Nonconformance documentation shall be prepared in accordance with QA-14.01 and shall include:

- A unique and traceable report number.
- The nomenclature and identification of the nonconforming article or material.
- A description of the nonconformance and the required characteristic or design criteria.
- The cause or reason for the nonconformance.
- Remedial actions taken or recommended.
- Disposition of the nonconforming article or material.
- Initiator of the document.
- Signatures of authorized personnel.

### **9.2 Material Review Board (MRB) / Failure Review Board (FRB).**

A Material Review Board (MRB) and Parts Control Board will also be formed prior to the start of production. Members of the board are shown in Figure 9-1. This board will review and disposition all Discrepancy Reports (DRs) and Nonconforming Material Reports (NMRs) that occur during manufacturing, assembly, and testing. This board will also review all Non-Standard Parts Requests (NSPARs). These discrepancies and nonconformances can be dispositioned by convening the board or quality assurance can secure approval from individual board members without actually convening the board. The FAME MRB shall make disposition in one of the following categories:

- Repair - When, in the opinion of the MRB, an acceptable repair is possible, repair action may be authorized. Procedures shall be established or approved by the MRB to perform this repair. Procedures shall include appropriate inspections and tests to verify the acceptability of the repair.
- Scrap - If the article or material is unfit for use, it shall be dispositioned in accordance with procedures for identifying, controlling, and disposing of scrap.
- Use As Is - Nonconformances which do not adversely affect safety, reliability, durability, performance, interchangeability, weight, controlled interfaces with other hardware or basic objectives may be accepted for use as is. The rationale for making a use-as-is disposition shall be documented on the nonconformance report.
- Return to Supplier - When an article of material is found to be nonconforming on receipt, it may be returned to the subtier supplier. The subtier supplier shall be provided with nonconformance information and assistance as necessary to permit remedial preventative action.



**Figure 9–1. FAME Combined Material Review Board and Parts Control Board**

### **9.3 Failure Reporting, Analysis and Control / Failure Review and Corrective Action System (FRACAS)**

Where appropriate, DRs will be supported by formal failure analysis. FAME will use a formal system for the control of failures that occur during the production, test, and check-out of flight units.

The purpose of this failure reporting system shall be to document all failures that occur during the production process to assure that the appropriate hardware repair is accomplished, and to assure that appropriate actions are taken to preclude failure recurrence.

Failures that occur on flight hardware shall be documented on the NCST Discrepancy Reporting Form in accordance with procedure QA-14.02.

The analysis of all failed parts will be performed by NCST or a specified contractor.

Failures in acceptance, qualification and development tests must be analyzed with FAME Program Manager participation. This will be accomplished by telecons, written communications, and on-site visits whereby the steps and schedule of the analysis process are mutually agreed upon by the subsystem engineer and FAME Program Manager.

Submittal of failure analysis report detailing the cause of failure and recommended corrective action shall be required within three (3) weeks. The approval of the failure analysis report by the FAME Program Manager shall be required before any hardware rework is accomplished.

### **9.4 Test and Checkout Anomalies.**

During test and checkout, all anomalies that occur will be identified and tracked on Test Anomaly Reports (TARs), as identified within the as-run procedure. These include all issues involving the test article, the ground test equipment, the test set-up and the test software. These anomalies can be closed out by the test conductor with subsystem lead concurrence. If in reviewing the anomaly, it is concluded that a failure has occurred or that a nonconformance exists, then the anomaly will be closed and an NMR or DR will be opened.

## 10. SOFTWARE QUALITY ASSURANCE

FAME software shall be developed, documented, controlled, tested, and verified in accordance with the *FAME Software Management Plan*, NCST-SDP-FM001. Quality assurance personnel shall support these activities in addition to software reviews and audits conducted as described in NCST-SDP-FM001.

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## **11. HANDLING, STORAGE, PACKAGING, AND DELIVERY**

### **11.1 Stores.**

Quality assurance shall maintain a secured stores area for all FAME components and subassemblies.

### **11.2 In-Process Handling and Storage.**

Critical handling instructions will be incorporated into the fabrication and assembly procedure. Each inspection operation should begin with a verification of the documentation accompanying the hardware.

### **11.3 Preservation, Marking, and Labeling.**

Articles and materials subject to deterioration, contamination or corrosion through exposure to air, moisture, or other elements during fabrication and storage shall be cleaned and preserved by methods which ensure maximum life and utility. Critical, sensitive, dangerous and high-value articles shall be given special attention.

### **11.4 Packaging and Shipping Control.**

Articles and materials shall be packaged to prevent deterioration, corrosion, damage, and contamination. Packaging procedures and instructions shall be utilized and provide for protection to articles and materials while at the contractor's facilities, during transportation to destination and upon arrival at destination.

The NCST and contractor shall provide for cushioning, blocking, bracing, or bolting, as applicable, to prevent rupture of flexible barriers, undesired free movement within containers, and the physical damage due to transmission of shock and vibration.

All packaging and packing shall be inspected for compliance with the program requirements. Records of inspection shall be maintained by quality assurance.

Shipping shall ensure that all applicable documentation, including shipping papers, are included with the shipment and that these documents are correct and complete. When all items are acceptable, including packaging and preservation inspections, the shipping papers shall be signed by the approved shipping clerk.

## **12. METROLOGY**

### **12.1 Calibration System.**

All measuring equipment and test equipment including fabrication fixtures and jigs utilized in the qualification and flight phases must be under a calibration control system consistent with the requirements of MIL-STD-45662.

### **12.2 Test Equipment List.**

The acceptance and qualification test reports are required to contain a list of the equipment involved in the tests with specific information of serial numbers and calibration dates.

### **12.3 Metrology Controls.**

The subsystem contractor personnel shall establish and utilized a documented metrology system to control metrology processes and provide calibrated equipment necessary for objective evidence of quality conformance. Calibration standards and equipment shall be selected and controlled to the degree necessary to meet the requirements of MIL-STD-45662. Calibration processes shall be performed in accordance with established written procedures. All special measurement equipment (e.g., automatic test and checkout equipment) shall be evaluated to verify that the standards and equipment measure the desired characteristics to the required accuracy; provide the desired indications or records; are compatible with the configuration of related hardware and environmental conditions; and operating instructions are correct and complete. Documented results of the evaluation shall be maintained by the subsystem contractor.

#### **12.3.1 Measurement Processes.**

Random and systematic errors in any calibration measurement process shall not exceed 25% of the tolerance of the parameter being measured and 10% of the tolerances of the article or material characteristic being measured. Authorization for exception shall be requested from NCST.

#### **12.3.2 Calibration Controls.**

The subsystem contractor shall have a documented procedure for the control of calibration of measurement standards and equipment. This procedure shall include traceability to standards maintained by the National Bureau of Standards; derived standard from a controlled measurement process utilizing a fundamental constant of nature; handling, storage, and transportation requirements that shall not adversely affect the quality, reliability or result in hazardous conditions; and unique identification, labeling, tagging or coding to indicate date calibrated, due date and acceptance stamp. The procedure shall also establish calibration intervals with periodic reviews and a recall system. Controls shall be established to ensure the immediate recalibration or removal from service of those found to exceed the established interval or which for any reason might have an adverse effect on quality. Individual calibration records of measurement standards and equipment shall be maintained and include identification of standard or equipment, calibration procedures, calibration intervals, dates and results of each calibration, due date of next calibration, individual(s) performing calibration, calibration facility and any nonconformance or repairs of standards or equipment received for calibration.

### **13. QUALITY ASSURANCE RECORDS, AUDITS, VERIFICATION, BUY-OFFS AND TEST READINESS**

#### **13.1 Records.**

The fundamental element to assuring a quality product is the development and maintenance of records at specific steps during manufacturing, test, and check-out. NCST records are defined in one of three manuals. These manuals are the *NCST Manual for Control Procedures*, NCST-MCP-001, the *NCST Manual for Manufacturing Procedures*, NCST-MMP-001 and the *NCST Manual for Quality Assurance Procedures*, NCST-MQA-001. Since all records are part of the quality process, they are identified as NCST-Quality Record-XXXX where XXXX refers to the procedure which specifies the use of the form.

#### **13.2 Audits.**

Physical audits will be conducted at various turnover points as defined in CP-03.04. A combined physical and functional audit will be performed before buy-off and at the TRR and the results included in the buy-off presentation and data package.

#### **13.3 Verification.**

Verification that the FAME hardware was fabricated, assembled, and acceptance tested to the correct engineering requirements will be accomplished by maintaining an ECL in accordance with procedure CP-09.07 and an ABCL in accordance with procedure CP-11.06. Verification will be made at intermediate turnover points as part of the physical audit and the results presented as part of the buy-off for major serialized components and subassemblies. The verification process is specified in procedure CP-03.03.

#### **13.4 Buy-Offs.**

A Flight Component Review (FCR) will be held for all major components and subassemblies. The subassemblies for which an FCR will be held and the review date will be identified in the program master plan. A buy-off is the point at which the program manager authorizes the incorporation of the component or subassembly into the next assembly or top assembly. The buy-off review and turnover process is described in procedure CP-03.04.

The elements and organization of the FCR data package and presentation leading to buy-off are summarized as follows:

- a. History
- b. Open issues
- c. NMR and DR summary
- d. Verification results
- e. As-run test results and test anomalies

#### **13.5 Test Readiness Review.**

A TRR will be held prior to system level testing as scheduled in the master program plan. The TRR will include a summary of the buy-off element listing in section 13.4 plus a review of the following additional items:

- a. Test plan
- b. Test procedure
- c. Test set-up and equipment
- d. Test article configuration and readiness including a summary of all buy-off items in section 13.4

## 14. NOTES

### 14.1 Abbreviations and Acronyms.

Acronym	Definition
ABCL	As-Built Configuration List
CCA	Circuit Card Assembly
CCB	Configuration Control Board
CDR	Critical Design Review
CP	Control Procedure
DR	Discrepancy Report
ECL	Engineering Configuration List
FAME	Full-sky Astrometric Mapping Explorer
FCR	Flight Component Review
FRACAS	Failure Review and Corrective Action System
FRB	Failure Review Board
FRR	Flight Readiness Review
MP	Manufacturing Procedure
MRB	Material Review Board
NCST	Naval Center for Space Technology
NMR	Nonconforming Material Report
NSPAR	Non-Standard Parts Request
PDR	Preliminary Design Review
PSR	Pre-Ship Review
SR&QA	Safety, Reliability and Quality Assurance
SRR	System Requirements Review
TAR	Test Anomaly Report
TRR	Test Readiness Review